Radiation Risk: The new era begins
Latvian Academy of Science
Riga 14th August 2009

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- Scientific Secretary: European Committee on Radiation Risk (ECRR)
- UK Ministry of Defence Depleted Uranium Oversight Board (DUOB)
- UK Dept of Health Committee Examining Radiation Risks from Internal Emitters (CERRIE)
- Leader: Science/ Policy interface; Policy Information Network for Child Health and the Environment (PINCHE; European Union).
- Guest Researcher: Julius Kuehn Institute, German Federal Agricultural Laboratories, Braunschweig, Germany
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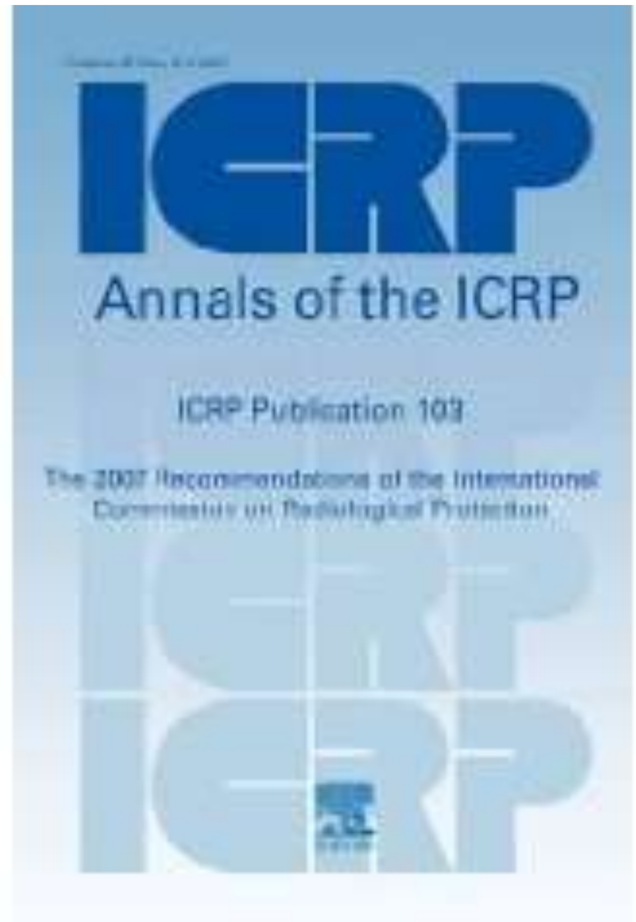
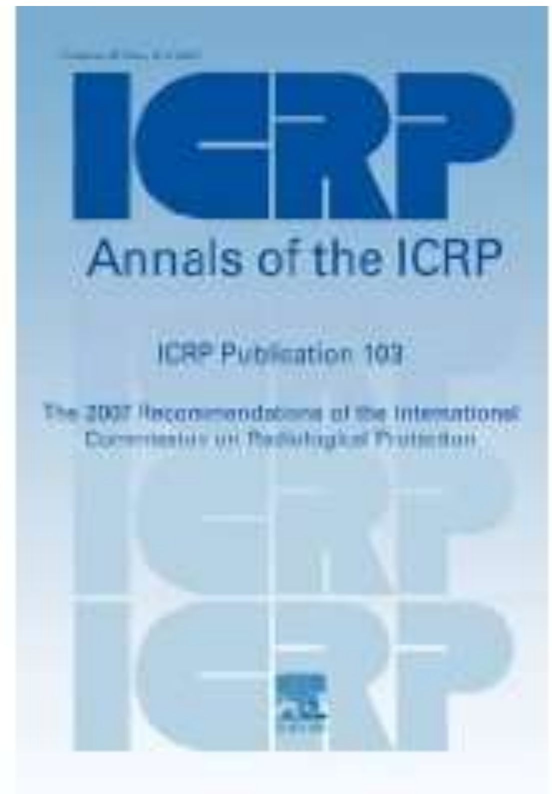
The ICRP radiation risk model, developed in 1952 and currently still the basis of legal limits has failed the human race and is now embarrassing in its manifest error

The most recent version of the ICRP model, Publication No 103 was released in 2007. National Governments are now in the process of adopting the model as a basis for laws on exposure.
The new model is the same as theold ICRP 60 1990 model.
For 20 years, the
ICRP, an independent charity based in the UK, has had one permanent staff member,
Dr Jack Valentin.



The report barely mentions Chernobyl. It fails to discuss or refer to a large number of peer-reviewed and published reports which show that its conclusions are incorrect.

This situation has now become embarrassing to the scientific community and to the commitment of scientific philosophy to accepting truth from experiment and from observation.



Example: Chernobyl evidence

It has been widely suggested that the effects of radiation exposure in the Chernobyl affected areas are not measurable and health deterioration of the population is due to social changes and 'radiophobia'.

This was cover up by the Soviet Authorities followed by a cover up by the UN bodies WHO and UNSCEAR.

This 2005 ECRR book has reviews of all the Russian language peer reviewed literature on the health effects.

There is a meltdown of the health of the Exposed population. All these data were ignored by ICRP.

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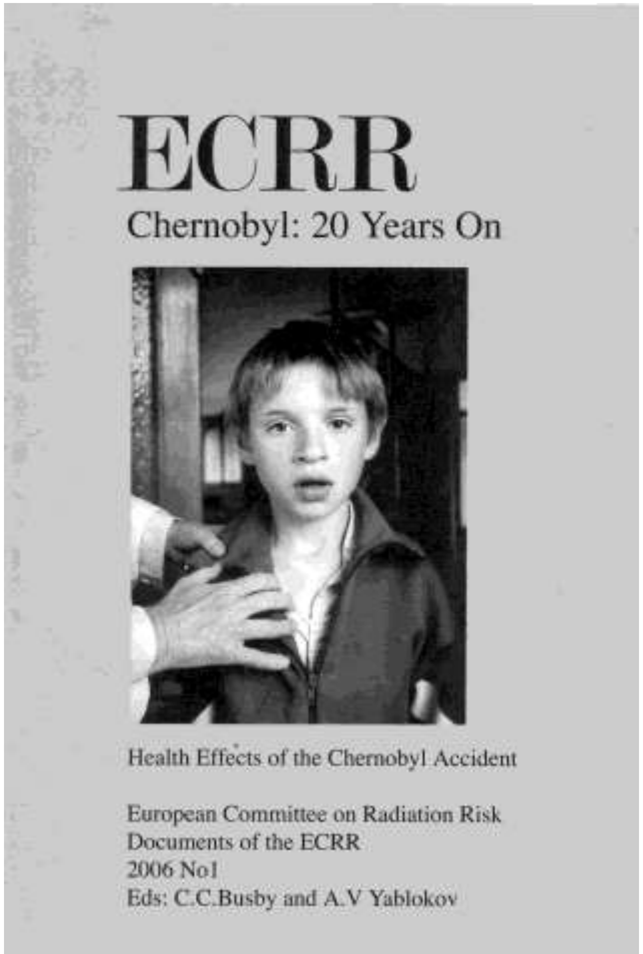


The EU funded Atlas of Caesium Contamination shows that significant quantities of Chernobyl fallout came to Latvia and Riga

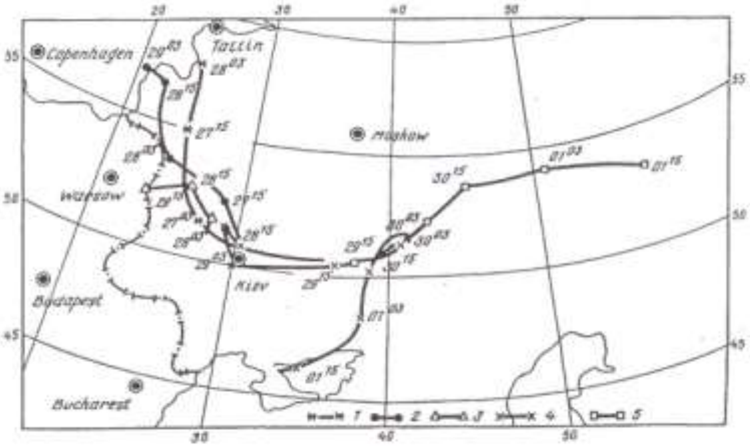


Fig. A.3: Trajectories of particle transport at height of 0,7 km: 1 - from 15.00 on 26 April; 2 - from 03.00 on 27 April; 3 - from 15.00 on 27 April; 4 - from 03.00 on 28 April; 5 - from 03.00 on 29 April

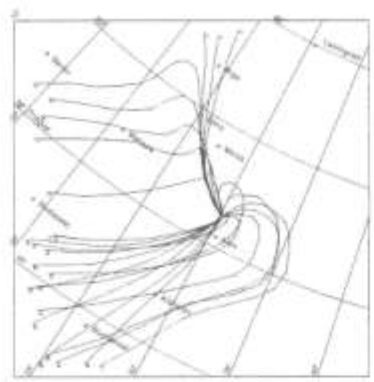


Fig. A.4: Trajectories of particle transport from the power plant region at the level of 925 hPa by 6-hour intervals from 24 April to 1 May 1986. The trajectories 1-4 : transport of momentary portion of particles on 26 April; Trajectories 5-8 on 27 April; Trajectories 21-24 on 1 May 1986.

Trajectories of particle transport at different heights in the atmospheric boundary layer are shown in Figures A.3 and A.4 for different periods of time after the start of the accident.

The variations in the mean wind direction and speed are illustrated in Figure A.5 for two heights in the atmosphere and at various locations (e.g., Kiev, Gomel). On 26 April, 1986, the area around Chernobyl was situated in a low pressure gradient with weak surface winds of variable direction. At a height of between 700 m and 1500 m (the effective height at which material was initially released in the accident) a south-easterly flow with wind velocities of 5-10 m s^{-1} transported the radioactive cloud to the north-west. This was confirmed by environmental measurements and the constructed trajectories of air masses at this height. Material released later on the 26 April was also largely transported to the north-west (in the 700 m to 1500 m layer of the atmosphere) with a subsequent turn to the north. In the layer close to the surface, material was initially transported westward and north-westward and reached the Polish border late on April 26 /early on 27 April. During the following days (27 to 29 April) material in the bound ary layer up to 200 m was transported north and

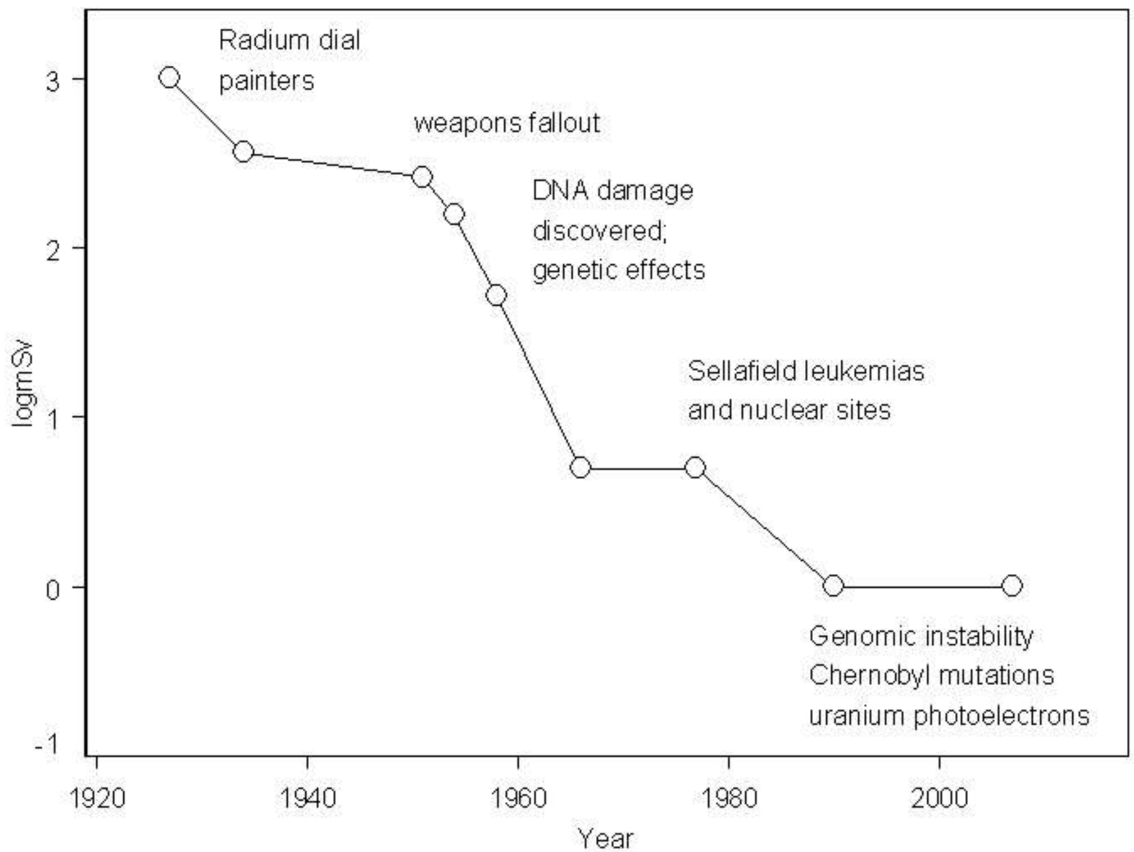
The Scientific Secretary of the ICRP was Dr Jack Valentin until March 2009. He has been the editor of many of the ICRP reports and was editor of the recent 2007 Updated risk model report, ICRP103.

At an open meeting in Stockholm on 22nd April after he had resigned, there was a discussion between Valentin and Busby about the merits of the ICRP risk model. Jack Valentin made some extraordinary statements.

Dr Jack Valentin said:

1. The ICRP risk model could not be used to predict the health effects of radiation exposures in human populations.
2. For certain internal exposures the errors in the model could be as high as two orders (100-999 times)
3. Now that he was no longer employed by ICRP he could agree that the ICRP committee and the United Nations radiation committee (UNSCEAR, whose publications the ICRP model depend on) had been *wrong* in not examining the evidence from the Chernobyl accident, and also much other evidence that showed the ICRP model to be incorrect for internal exposures.

But evidence that radiation exposures are harmful has continued to increase throughout the radiation century. There is no safe dose of radiation. The graph shows (log scale) the reduction in the legal dose limits from 1920 to the present.



In 1997, at an European Commission meeting on this issue in Brussels, Valentin was faced with these criticisms from many scientists; Dr Alice Stewart, Dr Rosalie Bertell, Dr Chris Busby, Dr Jean Francois Viel were the main speakers and critics. Valentin responded that ICRP was independent and that governments were free to take advice from anywhere they chose, from any committee they chose to consult.

- The result was the formation of the European Committee on Radiation Risk ECRR/CERI
- The First Report of the ECRR was published in 2003. It has been reprinted three times and translated into Japanese, Russian, French and Spanish.
- The new model of the ECRR uses broadly the same concepts as the ICRP model but includes new weighting factors for certain internal exposures e.g Sr-90, U-238

The Lesvos Statement, May 5th 2009

- Between 1997 and 2009, more than 40 radiation experts from countries all over the world joined the ECRR.
- At the 3rd International Conference of the ECRR on May 5/7th 2009 held on the Greek Island of Lesvos, in collaboration with the Environment Department of the University of the Aegean, more than 20 of these scientists from England, USA, Canada, Japan, India, Russia, Germany, Belarus, France, Ukraine gathered to make presentations of evidence of the adverse health effects of radiation exposures at very low internal doses.
- All of these renowned scientists discussed the serious inadequacy of the ICRP model and created and signed a statement calling for national and international bodies to abandon the ICRP model as a matter of urgency.

Among these scientists were

Prof. Shoji Sawada, Japan
Prof. Carmel Mothershill, Canada
Prof. Alexey Yablokov, Russia
Prof. Roza Goncharova, Belarus
Prof. Mikhail Malko, Belarus
Prof. Angelina Nyagu, Ukraine
Prof. Alexey Nesterenko, Belarus
Prof. Michel Fernex, France
Prof. Inge Schmitz Feuerhake, Germany
Prof. Daniil Gluzman, Ukraine
Prof. Chris Busby, UK
Prof Yuri Bandashevsky, Belarus

Dr Hagen Scherb, Germany
Dr Marvin Rsnikoff, USA
Dr Alfred Koerblein, Germany
Dr Sebastian Pflugbeil, Germany
Dr Christos Matsoukas, Greece

Others, who missed attending but sent presentations included:

Dr Keith Baverstock (Finland)
Prof. Elena Burlakova (Russia)
Dr Paul Dorfman (UK)
Dr VT Padmanabhan (India)

The Lesvos statement can be found at www.euradcom.org
The statement includes in the start:

- . . . B Whereas the ICRP risk model is used world wide by federal, state and government bodies. . .
- . . . C Whereas the Chernobyl accident has provided the most important. . opportunity to discover the yields of serious ill health following exposure to fission products. .
- . . . D Whereas, by common consent, the ICRP risk model cannot be validly applied to post accident exposures, nor to incorporated radioactive material resulting in internal exposure
- . . . E Whereas the ICRP risk model was developed before the discovery of DNA structure and that certain radionuclides have chemical affinities for DNA . . .

The Lesvos Statement continues:

1. We the undersigned assert that the ICRP risk coefficients are out of date and that (their use) leads to risks being significantly underestimated.
3. Assert that the yield of non-cancer illnesses from radiation . . . is significant. . .
4. Urge the responsible authorities. . . To no longer rely on the existing ICRP model. . .
5. Urge the responsible authorities and all those responsible for causing exposures to adopt a generally precautionary approach and in the absence of another workable model to apply with undue delay the provisional ECRR2003 risk model which more accurately bounds the risks reflected by current observations.

So we are in the middle of a scientific earthquake

Jack Valentin clearly was not prepared to continue to support such a rotten system and resigned.

However the ICRP model allows and underpins:

- The nuclear energy fuel cycle, mining to licensed discharges to eventual storage of waste.
- Military reactors (ships, submarines)
- Depleted Uranium weapons (Iraq, Afghanistan, Kosovo)
- Uranium mining
- Nuclear testing
- Many other areas e.g. Fertiliser uranium, prosthetic materials, nuclear medicine

I will now turn to the science: Problems with the model

- The basic assumptions are incorrect at the physical and chemical level
- Epidemiology shows effects which occur at ‘doses’ which the model predicts are far too low to show any effect
- In view of time I will discuss a few examples of the failure of the ICRP model. The main failures include the following:

Incorrect assumptions: theory and experiment

Theoretical: Absorbed Dose is a false concept

- External and internal isotope or particle doses confer hugely different ionisation density at the DNA
- Epithelia and organelles concentrate certain isotopes due to biochemical or biophysical affinity
- High local ionisation can make 2 strand break and should be proportional to Dose squared
- 2^{nd} Event decays can intercept the repair mechanisim
- DNA binding; membranes
- Z^4 (high Z elements uranium)
- Dose response is not linear and can be biphasic
- No inclusion of ionisation density enhancement near DNA from Auger or transmutation
- Genomic and bystander effects mean non-cancer effects and possible field cancerization

Incorrect assumptions: epidemiology and laboratory studies

Epidemiological observations of high risks at low doses : causality denied on basis of false model

- Chernobyl effects in ex-Soviet Union
- Chernobyl infants
- Child leukemias near radiation contaminated sites
- Nuclear site child cancer and adult cancer
- Sellafield/ Irish Sea
- Cancer epidemic and weapons fallout
- A-Bomb test veterans
- Gulf Veterans, A-Bomb veterans and Uranium
- Uranium effects in cell culture etc.

ICRP Linear No Threshold model:

- This model is physically simplistic
- It assumes that the outcome of exposure is cancer or leukemia
- It assumes that cancer yield is linearly proportional to a quantity named **absorbed dose**
- It assumes that the relationship between cancer and absorbed dose is given by studies of external acute radiation exposure, mainly the lifetime study of Japanese A-Bomb victims (Hiroshima, Nagasaki) who were exposed to the flash, compared with Japanese people who moved into the destroyed towns after the bomb.

How does radiation cause cancer?

1. Ionising radiation, whatever its source or type, is absorbed by materials with the creation of charged particle tracks which leave structured paths of ions and reactive chemical species.
2. It is these fragments that react with DNA and cause fixed mutations and cancer.
3. It is the density of the ionisation in the track that is the key quantity, not the average dose, the Absorbed Dose

ICRP phantom: body is modelled as a bag of water and radiation is assumed external. ABSORBED DOSE is ENERGY divided by MASS, Joules/Kg = Gray

This method gives same dose for warming yourself in front of a fire or eating a hot coal.

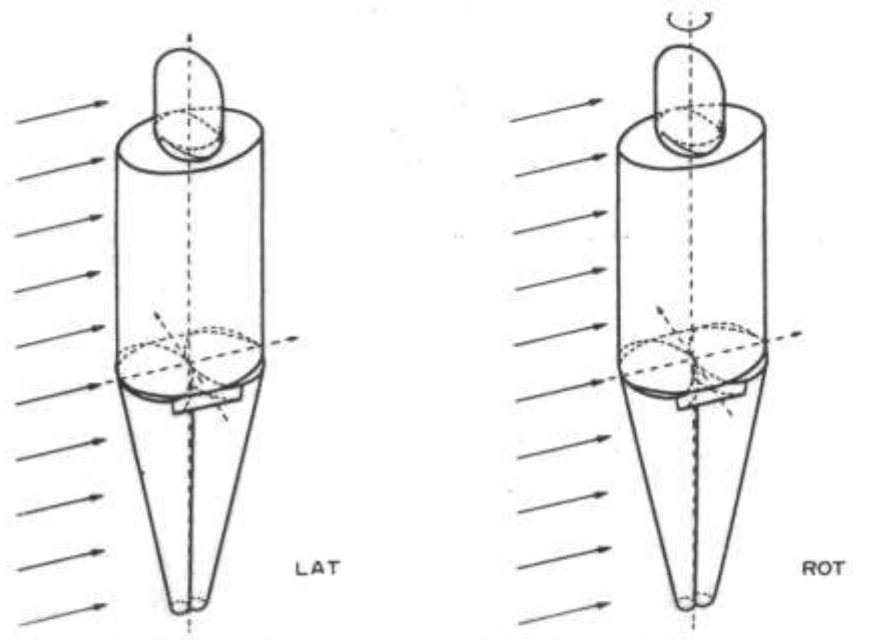
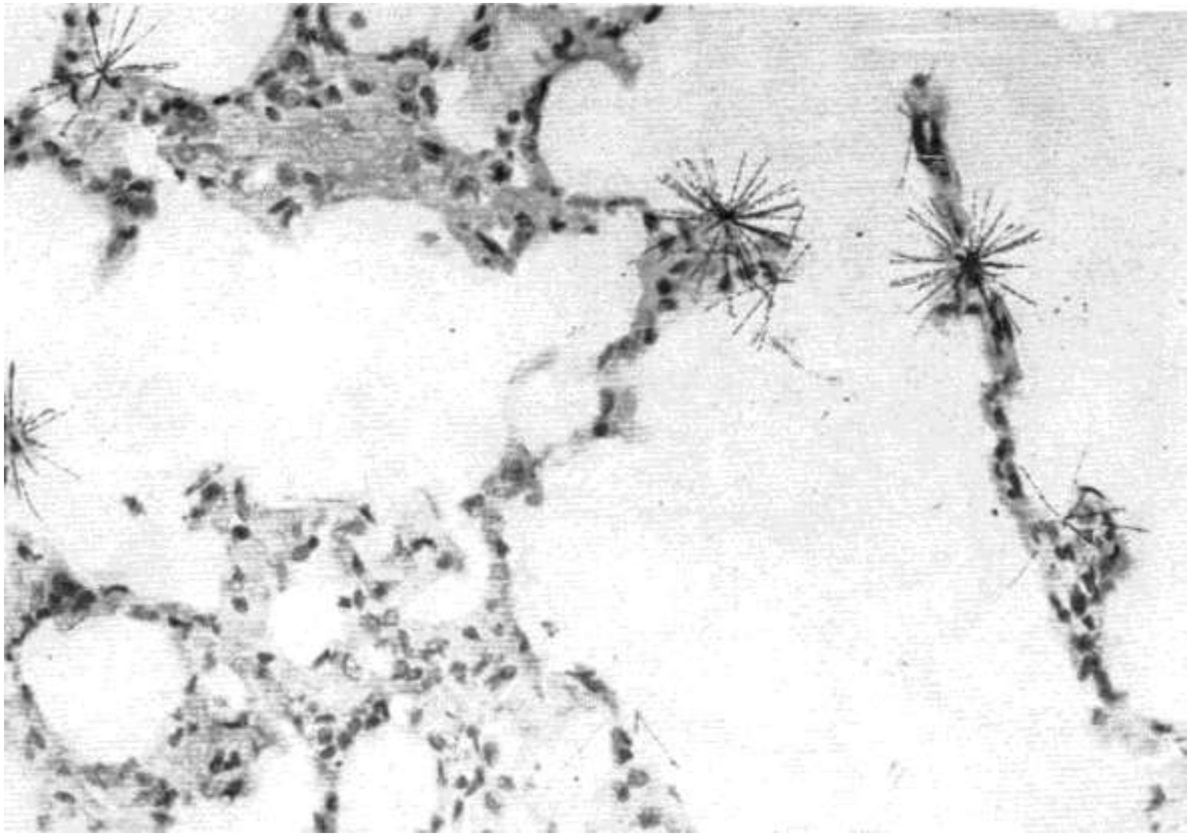


Fig. 1. Some irradiation geometries with an anthropomorphic phantom.

Alpha particle decays- micron diameter particles of Plutonium particle in a rat lung: ‘alpha stars’; high ionisation at local positions even though ICRP dose is “safe”



The target for radiation effects is the cellular DNA

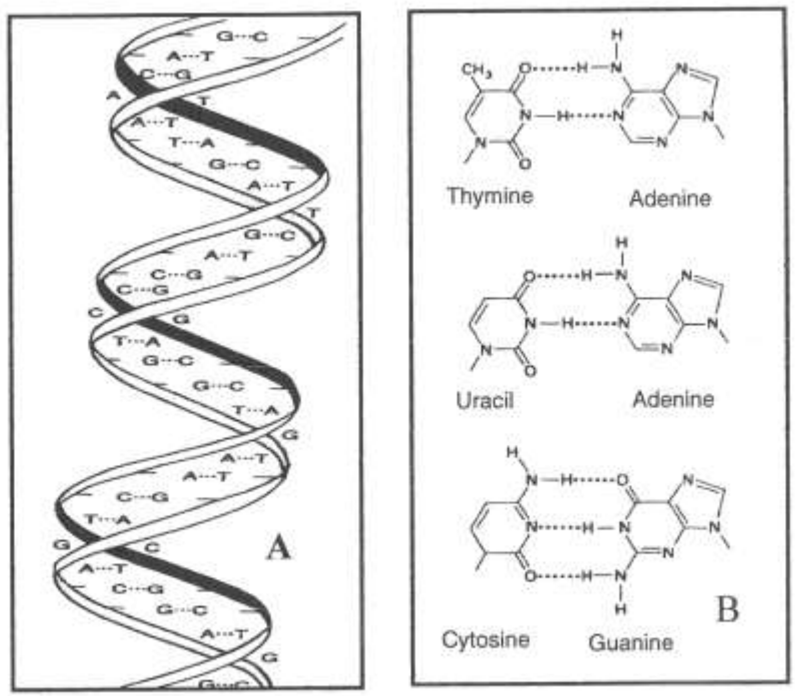


FIG.2.7. A: The double helix structure of DNA showing complementary bases arranged opposite one another; B: the molecular structure of the DNA bases showing Hydrogen bonding between complementary pairs.

For many internal exposures, there are situations where the local dose at the DNA or critical tissue is very much higher than the average absorbed dose; examples:

- Elements that chemically bind to DNA because of high chemical affinity, Strontium-90, Barium-140, Plutonium-239, Uranium.
- Elements that are absorbed as massive micron diameter particles, hot particles e.g uranium weapons, nuclear release fuel particles, Chernobyl reactor particles
- Elements that form part of a series that decays with fast daughter isotopes e.g. Sr-90, Tl-132, BA-140
- Elements with low energy short range decays e.g. Tritium where low dose = many hits
- Elements that are not necessarily radioactive but amplify natural background gamma radiation through photoelectron emission e.g. Uranium, Platinum, Gold.

The ECRR2003 model assigns weighting factors to these types of internal exposures. These factors are based on assessment of epidemiological studies and on theoretical ionisation density calculations. Epidemiological evidence includes:

- Childhood leukemias near nuclear sites where exposures must be by inhalation
- Infant leukemia in Europe after Chernobyl exposures in utero
- Cancer in populations differentially exposed to atmospheric nuclear test fallout in the 1960s
- Cancer and leukemia near the shores of the radiation contaminated Irish Sea

The application of the ECRR 2003 model always gives the observed cancer yield e.g. In Belarus after Chernobyl.

In 2008, the largest study of child leukemia near nuclear sites was carried out in Germany by the KinderKrebs Register. The KiKK study of children living near nuclear sites in Germany 1980-2004 confirmed the existence increased child leukemia rates in those living <5km

Nuclear Site	Year established	Defined ICRP Risk Multiplier	Notes
[a]Sellafield/ Windscale	1983	100-300	Well studied by COMARE: high level of discharge to atmosphere and sea
[a]Dounreay	1986	100-1000	Well studied by COMARE: particle discharges to atmosphere and sea.
[a]La Hague	1993	100-1000	Particle discharges to atmosphere and sea: ecological and case control studies
[c]Aldermaston/ Burghfield	1987	200-1000	Well studied by COMARE: particle discharges to atmosphere and rivers
[b]Hinkley Point	1988	200-1000	Discharges to offshore mud bank
[d]Harwell	1997	200-1000	Discharges to atmosphere and river
[b]Kruemmel, Germany	1992	200-1000	Discharges to atmosphere and river
[d]Julich, Germany	1996	200-1000	Discharges to atmosphere and river
[b]Barsebaeck, Sweden	1998	200-1000	Discharges to atmosphere and sea

[a]Reprocessing plants discharging to sea; [b]Nuclear power station discharging to sea or river; [c]Atomic weapon and nuclear material fabrication plants; [d]Atomic research with discharges to local rivers

Table 11.1 Studies establishing excess leukaemia and cancer risk in children living near nuclear sites.

These many peer reviewed studies began with the Sellafield Gardner study in the 1980s. The only explanation is an error in the ICRP risk model of about 400-1000-fold for such exposures.

- Scoping the exposures leaves only one possibility. The causal exposure route is inhalation or ingestion of material released by the plants or re-suspended from contaminated environments.
- The error factors are supported by the Chernobyl Infants studies. Examination of increased infant leukemias after Chernobyl in four countries in Europe where ICRP doses were known accurately (Greece, Germany, Scotland, Wales) showed leukemias in infants who were in the womb at the time of the Chernobyl fallout contamination. The ICRP error defined by these observations was 400-1000 fold.

Increases in leukemia in infants in Wales and Scotland following Chernobyl: Evidence for errors in statutory risk estimates and dose-response assumptions.

Paper presented at the 3rd International Conference
HEALTH EFFECTS OF THE CHERNOBYL ACCIDENT:
RESULTS OF 15-YEAR FOLLOW-UP STUDIES
Organised by Physicians of Chernobyl/ World Health Organisation
Kiev, Ukraine June 4-8

Chris Busby, PhD
Molly Scott Cato, MA, MSc, PhD

Whole body Caesium trends

Figure 2
Whole body content of Caesium-137 + Caesium-134 measured in the two years following Chernobyl. (source: Etherington and Dorrian (5))

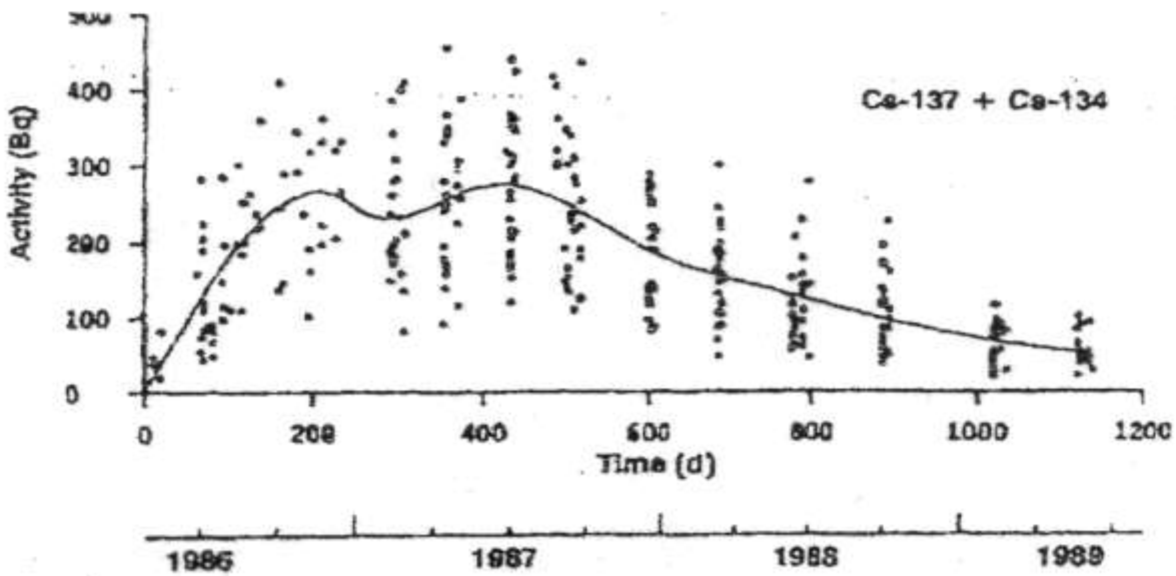


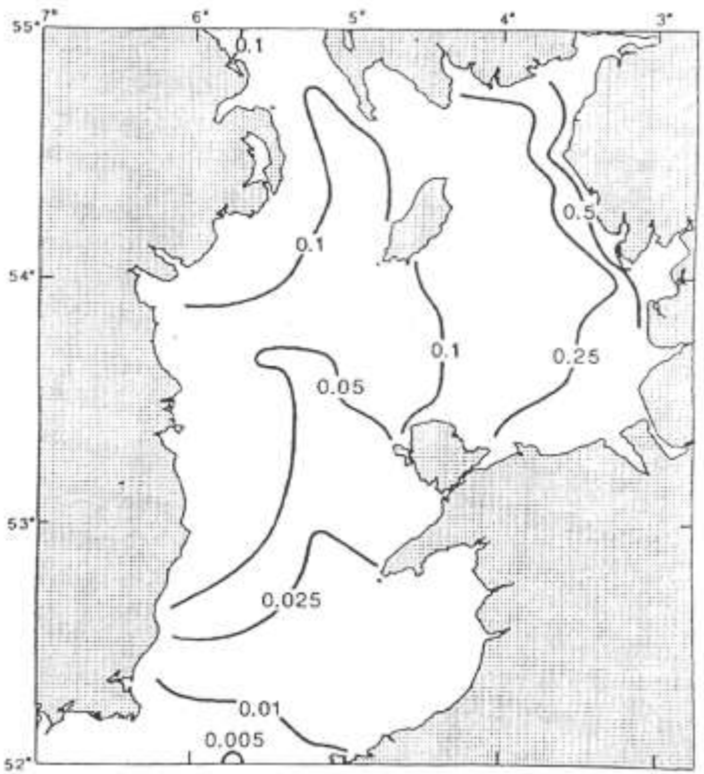
Table 2
Infant leukemia (ages 0-1) in Scotland and Wales and both countries combined (Source: Wales Cancer Intelligence Unit, Scottish Health Services)

Year	Scotland	Wales	Both	2-year groups
1975	1	0	1	
1976	3	0	3	4
1977	1	2	3	
1978	2	0	2	5
1979	0	0	0	
1980	2	0	2	2
1981	4	0	4	
1982	0	1	1	5
1983	1	0	1	
1984	3	0	3	4
1985	1	1	2	
1986	0	1	1	3
1987	6	0	6	
1988	4	4	8	14
1989	2	1	3	
1990	2	1	3	6
1991	0	1	1	
1992	3	2	5	6
1993	3	1	4	
1994	1	0	1	5

Note: In the period 1st Jan 1987 to 30th June 1988 there were 3 cases in Wales and 9 in Scotland

Sellafield

Sellafield and the Irish Sea

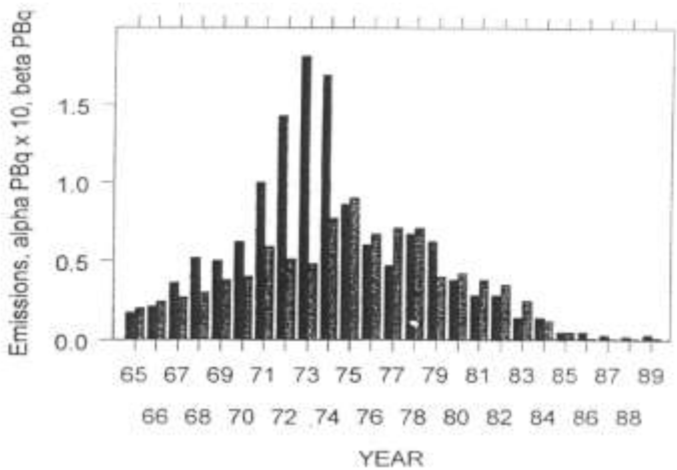


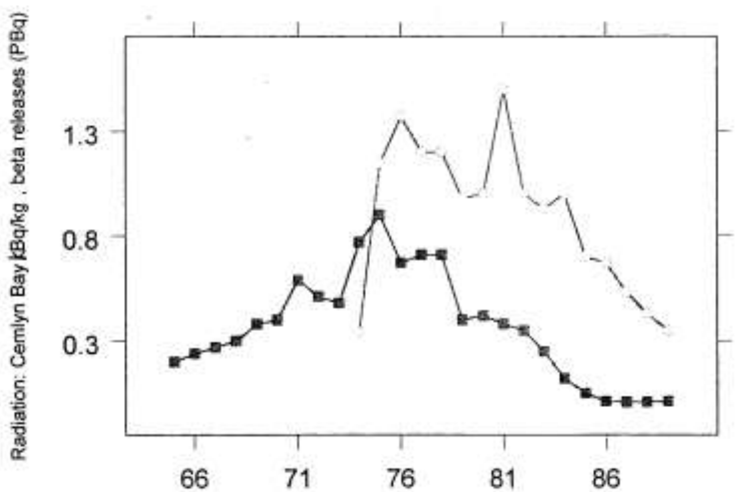
The Irish Sea has restricted and local circulation and is effectively closed at the north entrance. Insoluble material discharged from the Sellafield pipeline becomes attached to sediment and then is redistributed by tidal currents and concentrates in coastal areas where the tidal energy is low. This results in three areas of concentration:

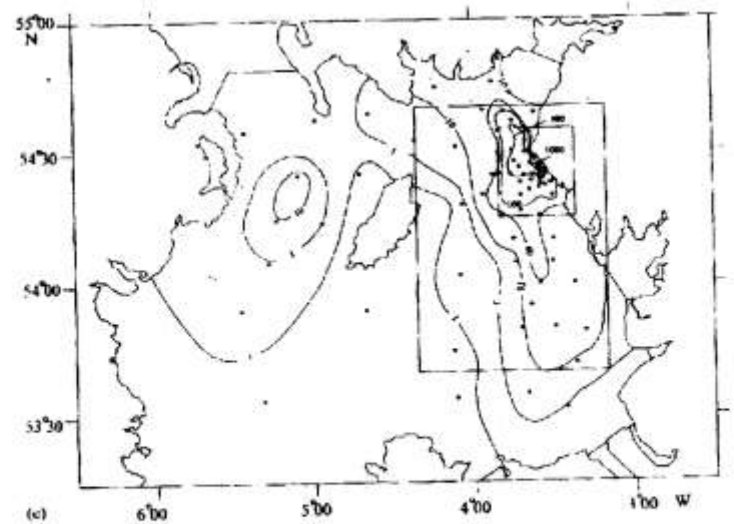
•The coastal areas of Cumbria (e.g. Seascale and coastal villages

•The North Wales Coast (e.g. the Menai Strait, Carnarfon and Bangor)

•North East Ireland (e.g. Dundalk and Carlingford Bay


Emissions, alpha PBq x 10, beta PBq
0.0
0.5
1.0
1.5
65 67 69 71 73 75 77 79 81 83 85 87 89
66 68 70 72 74 76 78 80 82 84 86 88
YEAR


Radiation: Cemlyn Bay kBq/kg , beta releases (PBq)
0.3
0.8
1.3
66 71 76 81 86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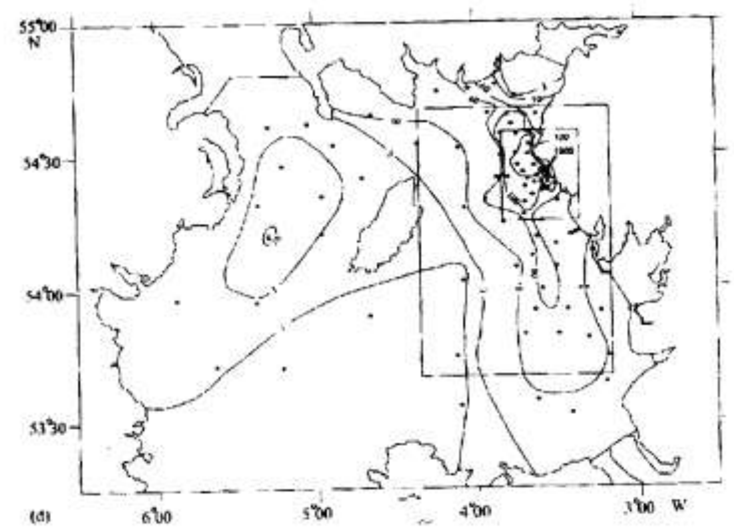
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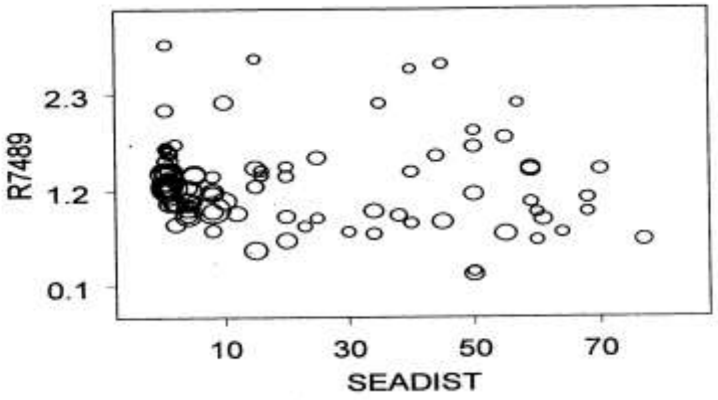
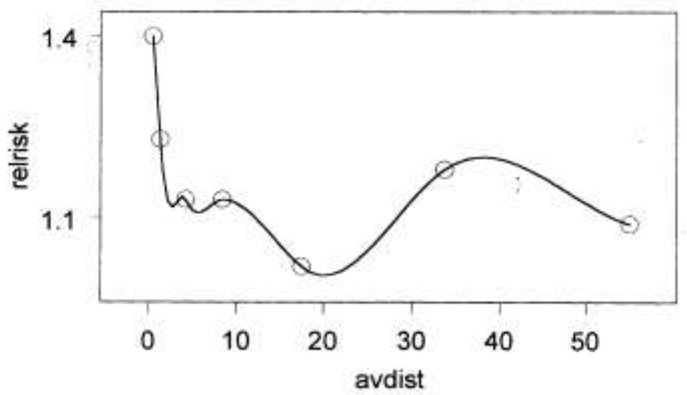
Plutonium and Caesium and other isotopes attach to fine mud in bays and estuaries. This is Carlingford, in County Louth photographed at half-tide. Sellafield isotopes are found here by the Irish Radiological Protection Institute (IRPI). Data from local GP Andy MacDonald analysed by Green Audit in 1998 showed a 4.6-fold excess of child leukemia in the period 1965-85. Ireland had no national cancer registry until 1994.

Results for Adults: Wales 1974-89

Seadist range Km	Average (SD)	N AORs	Oberved 74-89	Expected 74-89	Relative Risk	P value
<0.8	0.56 (0.17)	17	14445	10419	1.4	0.0000
0.9<x<2	1.38 (0.51)	13	11714	9559	1.23	0.0000
2.1<x<5	4.27 (0.47)	10	8283	7290	1.13	
5.1<x<11	8.44 (0.88)	10	8358	7388	1.13	
11.1<x<20	17.5 (2.32)	12	4294	4231	1.02	
21<x<40	33.67 (6.5)	12	2995	2524	1.18	
>41	55 (9.5)	23	7153	6579	1.09	
S Wales E=2		65	125054	105201	1.13	
Wales		193	207272	174675	1.12	





This shows results for all malignancy all adults 1974-89. The details for the AOR bands are given in the table above. Top right is a bubble plot of the individual RRs, radius weighted for expectation by distance from the sea. Bottom right shows a LOESS plot of the risks in the AOR bands. Note the sharp increase in risk in the 1km strip. This is a common feature of the results for adults and children.

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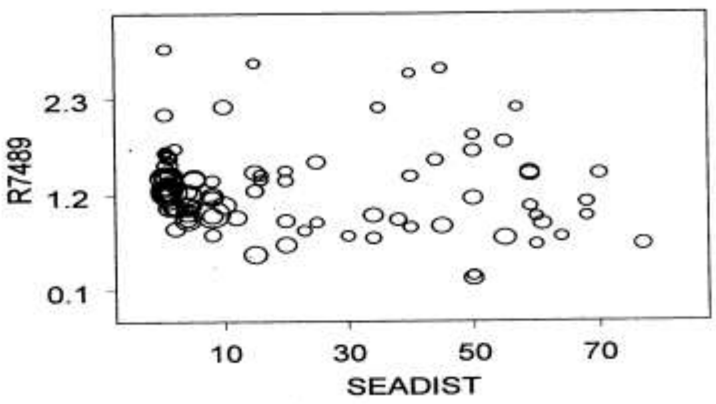

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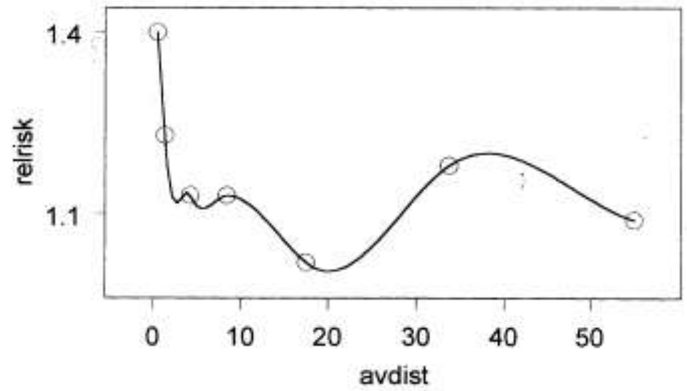
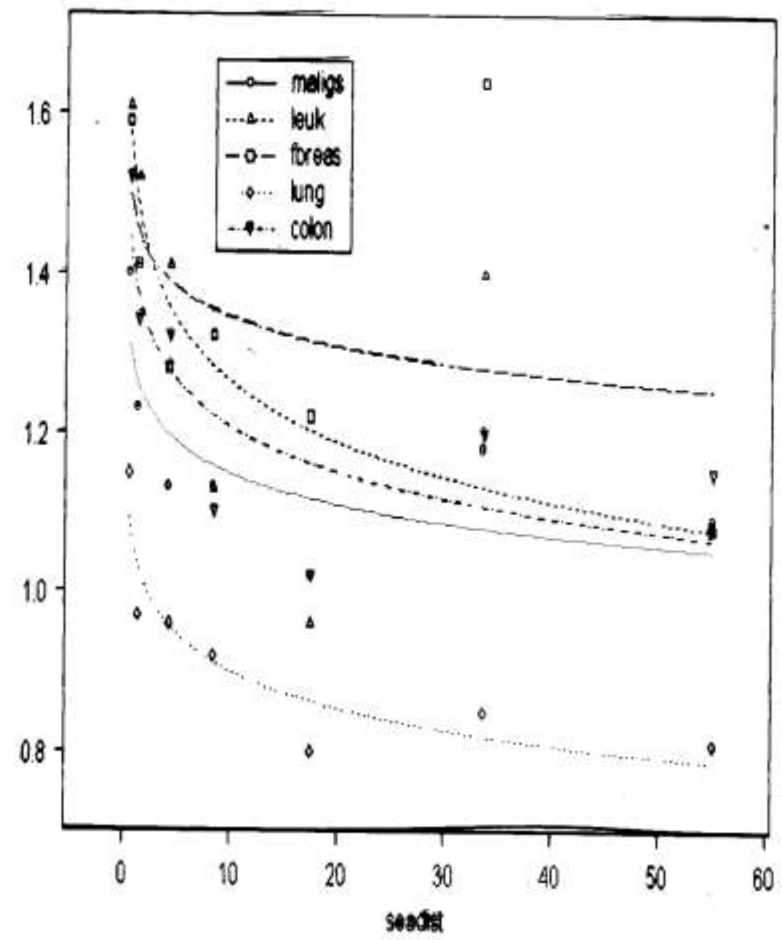


The sea coast effect was seen in most of the main cancer sites in adults and was much greater in children

- The graph shows an exponential fit to data points for RR in the AOR bands for all malignancy, leukemia, female breast cancer, lung and colon cancer in adults. For all of these the regression of SEADIST (distance from the sea) on log(RR) was statistically significant at p<0.05 level.
- The effect was driven by high risks in towns on the North Wales coast near known areas of radioactive pollution in the intertidal sediment.



Childhood cancer in Wales by distance from Irish Sea (km)

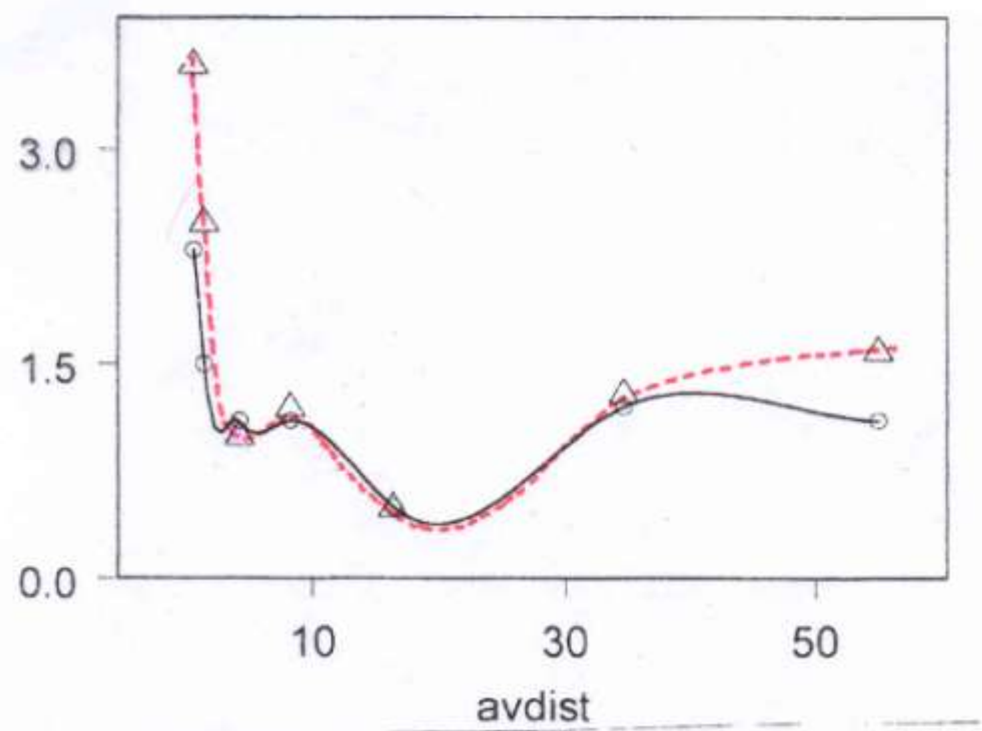
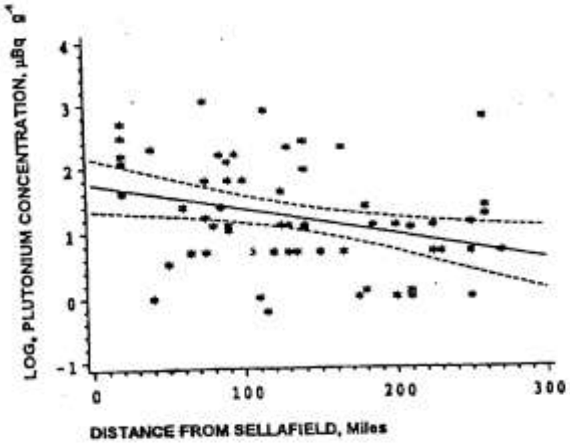
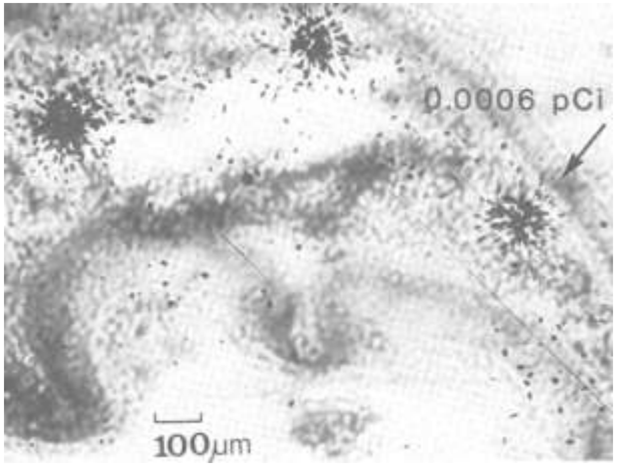


Fig 7. Childhood cancer in Wales 1974-89. Relative Risk trends 0-4 age group (177 cases) aggregated into AORs by distance from Irish sea . (Circles and line 1974-89, triangles 1984-88).

The painting by a Welsh artist, Steven Jones, and is of two little girls in the sea on the Menai. Top right: Plutonium in childrens' teeth by distance from Sellafield (log scale). Bottom: hot particle in edible mussel, CR39 tracks.





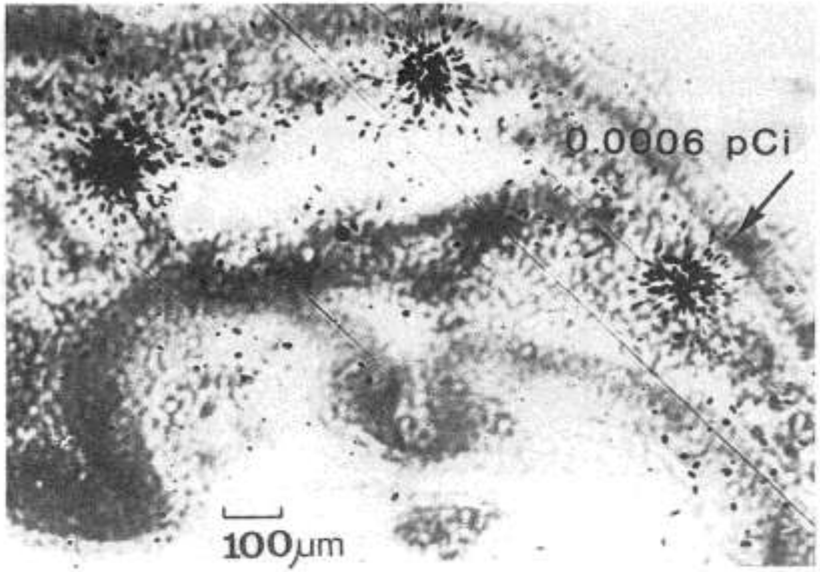


Fig. 1. *Mytilus edulis.* Thin section across the lumen of the intestine of Ravenglass individuals, illustrating the presence of hot particles recorded in CR39 detector superimposed upon the section. Exposure period 166 d

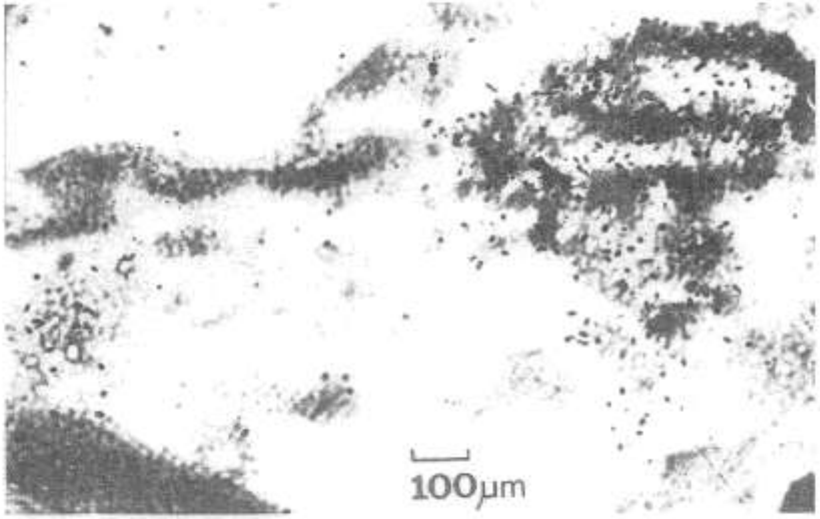
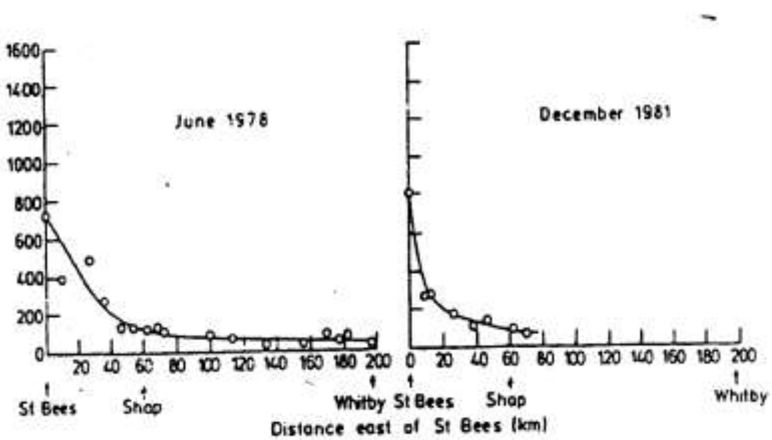


Fig. 2. *Mytilus edulis.* Distribution of α activity in a transverse kidney section of Ravenglass individuals, illustrating localised enriched levels of activity. Exposure period 166 d. Procedures as in Figure 1

Penetration of Plutonium inland follows penetration of sea derived particles, mainly sodium chloride.

In USA the map opposite shows this (Junge 1963). Below, concentration of Pu-239 in sheep faeces across UK on West East transect from Sellafield. Bottom right, the formation of the ejected particle from seaspray.

Penetration of seaspray inland in the USA
Ocean derived Chloride ion concentration
from Junge 1961



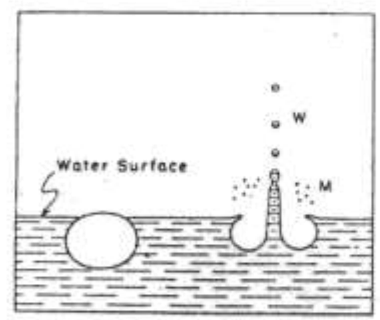
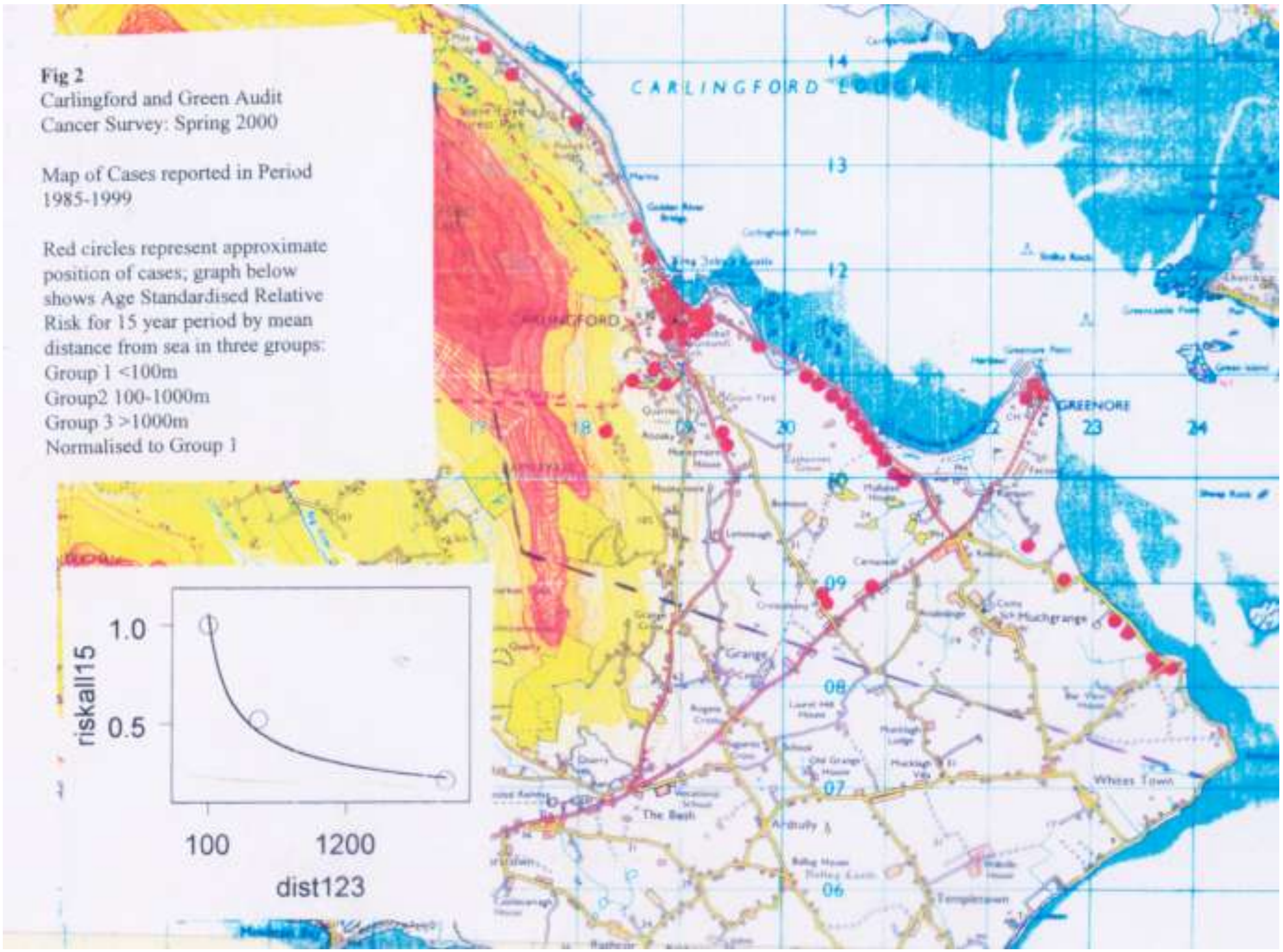
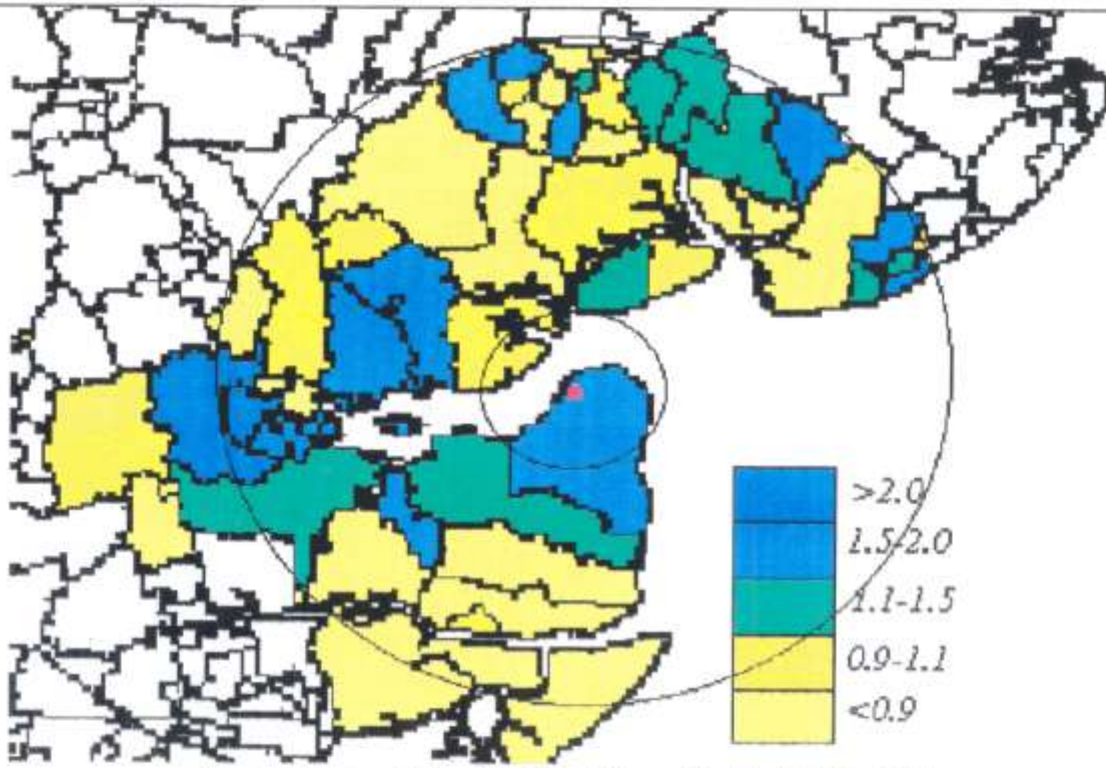


FIG. 34. The formation of sea-salt particles from the bursting of bubbles. The large droplets *W* originate upon disintegration of the jet and have been studied by Woodcock and his associates (Kientzler *et al.* 1954). More numerous and smaller particles *M* can form from the bursting of the bubble film (Mason, 1954).

Results of STAD/ Green Audit questionnaire study in Carlingford and Greenore, Ireland, 2000;
red dots are cancer cases; blue region is contaminated mud.



Breast cancer mortality in wards near contaminated mud near Bradwell NPP, Essex, UK



Breast cancer mortality risk within 20 km of Bradwell 1995 - 1999
relative to England and Wales (England and Wales = 1)
(The circles are at 4 km and 17 km from Bradwell nuclear power station)

I turn to Uranium and photoelectrons. This research is new. It was published last year and reported in the New Scientist in September 6th 2008 as the main news story

- Following the military use of depleted uranium in Iraq and elsewhere, and the increases in leukemia, cancer and birth defects, there has been increased inherent in the genotoxic effects of uranium.
- Many studies have shown such effects but there has been no plausible mechanism suggested.
- In 2003 in the UK government CERRIE committee and in the UK Ministry of Defence depleted Uranium Oversight Board I drew attention to the ability of Ureanium to bind chemically to DNA and also to absorb natural background gamma radiation owing to its high atomic number (92).

I have been interested in the health effects of uranium since 1997. I visited Kosovo and Iraq in 2000 and 2001 and was the first to detect and measure depleted uranium in Kosovo.

Secondary Photoelectrons

- Since 2003 I have been drawing attention to the Photoelectric Enhancement (PE) of natural background radiation by elements of high atomic number Z. Uranium has the highest atomic number (Z=92) for all naturally occurring elements.
- This has led me to look at the idea of ‘heavy metal’ toxicity and carcenogenicity
- We need to consider what is really going on in the cell when the DNA is mutated by an agent. What is ‘Oxidative Stress’ and where else do we see it? We see it after radioactive exposure. But with Uranium, there is not enough intrinsic radioactivity. Is there?

Fact (1) : Absorption of gamma and X-radiation is proportional to the fourth power of the atomic number Z

Material	Z	Z^4	$H_2O = 1$
H_2O	3.33	123	1.0
DNAP	5.5	915	7.4
Ca	20	0.15E6	1220
Sr	38	2.1E6	17,073
Ba	56	9.8E6	79,675
Au	79	38E6	308,943
U	92	72E6	585,365

And Fact (2): Uranium, as UO_2^{++} (uranyl) binds strongly to DNAP

- The affinity constant is $10^{10}M^{-1}$ measured by Nielsen et al (1992)
- This means that at a concentration of

$10^{-10}M$ (23.6ng/l) the DNAP will be half-saturated at a stoichiometry of 1 mole uranium to 2 moles PO_4^{--} .

The affinity for DNAP was first pointed out in 1961 when it began to be used as an electron microscope stain:

Huxley and Zubay (1961) stated that DNA takes up its own dry weight in uranium from a 2% fixing solution

Evidence for this effect; it is not a new idea

- Photoelectron enhancement of dose has been examined since Speirs (1949) calculated that there is an enhancement of 10-fold near bones in X-raying
- Since then, Matsudeira *et al (*1980) used Iodine contrast media to enhance X-ray radiotherapy
- Castillo *et al* (1988) showed enhanced doses near mandibular reconstruction plates
- Regulla *et al* (1998) measured 100-fold photoelectron enhancements near gold foils
- Herold *et al* (1999) used 400nm gold particles to enhance X-ray doses in radiotherapy
- Hainfeld *et al* (2005) showed that gold 10-50nm nanoparticles (Z=79) could be successfully used to enhance X-ray radiotherapy for tumours in mice and **patented the method**.

I am currently researching these Uranium effects in collaboration with colleagues at the University of Ulster. Initial photoelectron computer models show that the predictions are accurate.

- Uranium particles trap natural background gamma radiation and release the energy as photoelectrons directly into the DNA
- The ICRP has been examining this issue since I raised it; they have not yet responded
- But shortly after it was raised, Jack Valentin resigned.
- I show the initial CERN FLUKA results on the next slide.

Nanoparticles and Radiation

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Interaction of Radiation and Matter

Electromagnetic radiation and matter interact predominantly by three different mechanisms:

Compton scattering, the photo-electric effect and pair production. Compton scattering basically describes the loss of incident photon energy by the scattering of shell electrons. Pair production is the simultaneous production of an electron and a positron and occurs at photon energies above 1.022 MeV, which is equivalent to the invariant mass of an electron plus positron. With the photo electric effect, electrons absorb the incident photon energy and are either emitted or lose energy in secondary processes. For energies below 1 MeV, the photoelectric effect is the predominant one. The cross section σ for the photo-electric effect is proportional to Z (atomic number) to the power five and roughly proportional the incident photon energy to the power -7/2:

$$\sigma \propto Z^5 E_\gamma^{-7/2}$$

Most of the photoelectrons produced in an absorbing material lose their energy through electron-electron scattering and Bremsstrahlung. Therefore, the escape depth of photoelectrons generated within solids is usually of nanometers[1]. Hence, irradiated particles with diameters in the range of a few nanometers will emit most of the generated photoelectrons without internal reabsorption.

Therefore, nanoparticles are likely to emit the largest quantity of secondary electrons proportional to their mass.

Furthermore, secondary electron emission of high Z materials could provide a partial explanation of the toxicity of various heavy metals.

Due to their size, nanoparticles can penetrate into the human body and some are able to reach the cell nucleus. This may be crucial in explaining the toxicity of incorporated nanoparticles of materials with a high atomic number Z[2,3].

Monte Carlo Simulations

Monte Carlo Simulations are widely used in computational and statistical physics, physical chemistry and high energy physics to model particle transport and particle-matter interactions. We employed FLUKA[4,5], a Monte Carlo code to simulate the interaction and propagation in matter of different particles. FLUKA is capable of simulating particle interactions from 1 keV to TeV for different leptons, hadrons and bosons with high accuracy. We modeled photon absorption and secondary electron production of particles from 1cm to 1 Å for incident photon energies in the keV region. Target materials we used were water, gold and uranium. Fig.1 shows the arrangement of incident photon beam and target, Fig.2 shows secondary electron production energy deposition. Fig.3 illustrates the ratio of secondary electron production to primary incident photons and Fig. 4 shows the same ratio but weighted with the beam projection area and the target volume.

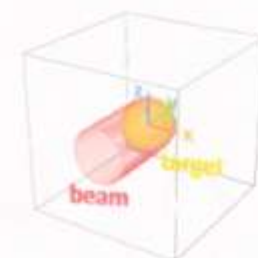

Fig.1: beam and target geometry

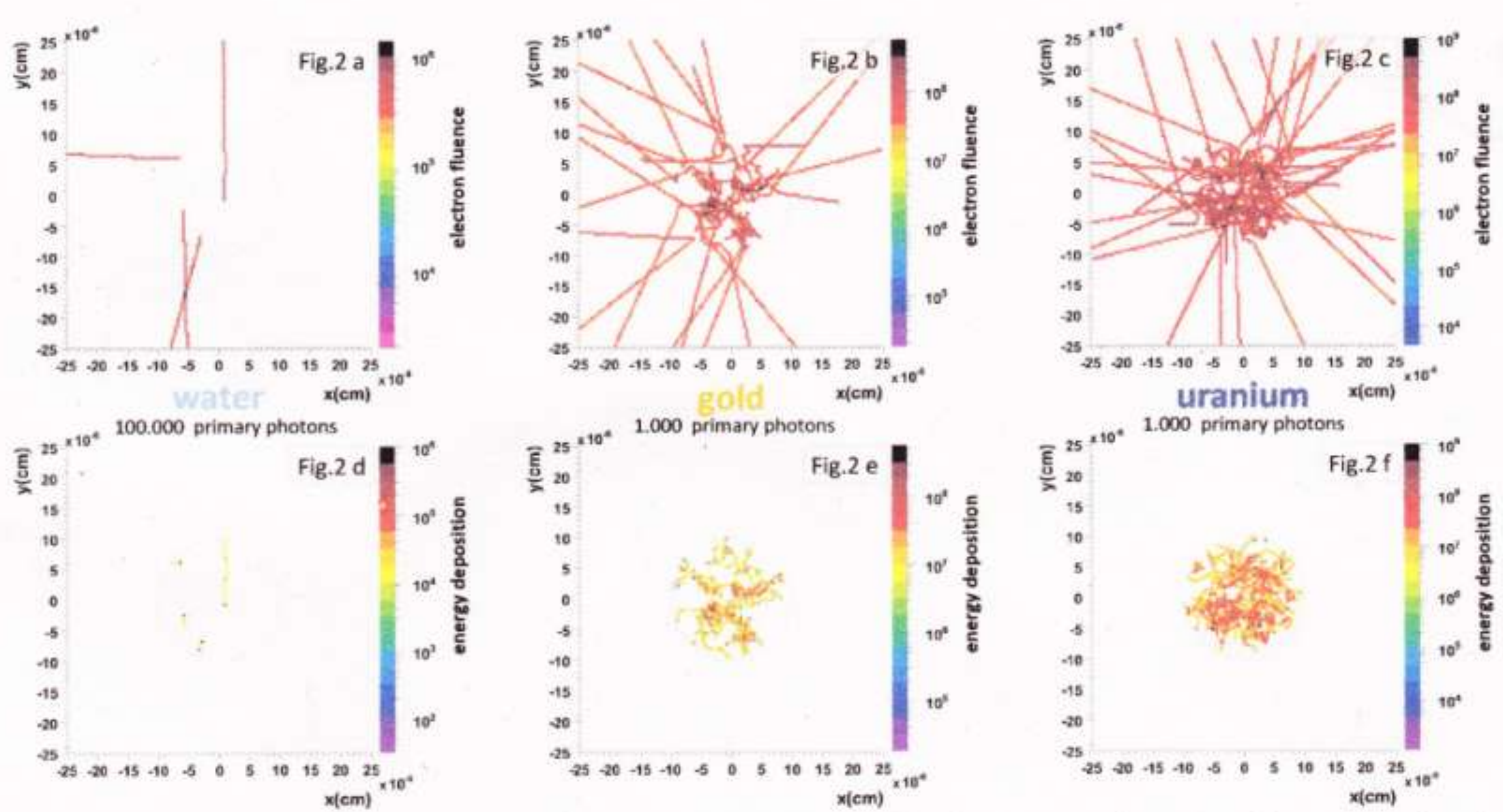

Fig.2: secondary electron production by 100 keV primary photons within the target and escaping electrons overlayed by the target geometry for water (a), gold (b) and uranium (c).Fig.2 (d)-(f) shows the corresponding energy depostion.
Fig.3: ratio of electrons leaving the target material (gold) to incident primary photons (100 keV, 10 keV, 2 keV).
Fig.4: same ratio as Fig.3 but weighted with the perpendicular beam projection area and the target volume.

Conclusions

The ICRP model, on which all current radiation risk laws for human exposures is based, is finished. It is scientifically bankrupt.

ECRR calculations show that this has resulted in more than 60 million excess cancer deaths worldwide due to exposures up to 1995 (principally from atmospheric tests).

The ECRR 2003 model makes clear that the contamination of the environment from nuclear discharges comes at a very great cost in human suffering for those now living and their descendants.

The committee continue to refine the model and a new version which includes photoelectron effect factors will be published in 2010

The ICRP model must be abandoned as a matter of urgency

Releases of fission product radionuclides and uranium to the environment must be strictly regulated on the basis of the ECRR2003 risk model,

Otherwise there will be more sick adults and sick children.

Development of nuclear energy must be based on political decisions that address the true effects.